OPIC
OFFICE DE LA PROPRIÉTÉ INTELLECTUELLE DU CANADA

CIPO
CANADIAN INTELLECTUAL PROPERTY OFFICE

Ottawa Hull K1A 0C9

(21) (A1) 2,167,951
(22) 1996/01/24
(43) 1997/07/25

(51) Int.Cl.[6] B02B 5/02; C07G 1/00

(19)(CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Methods for Dehulling of Flaxseed, Producing Flaxseed Kernels and Extracting Lignans and Water-Soluble Fibre from the Hulls

(72) Cui, Wuwei - Canada ;
Mazza, G.(Joe) - Canada ;

(71) Same as inventor

(57) 20 Claims

Methods for Dehulling of Flaxseed, Producing Flaxseed Kernels and Extracting Lignans and Water-Soluble Fibre from the Hulls

Inventors: Wuwei (Steve) Cui[1] and G. (Joe) Mazza[2]

1: 26 Inverary Drive, Kanata, Ontario, Canada K2K 2R8

2: 187 Stevens Crescent, Penticton, British Columbia, Canada V2A 8A6

ABSTRACT OF THE DISCLOSURE

A dry process for dehulling has been developed in order to utilize all components of flaxseed. The dehulling process is composed of three steps: first the flaxseed is dried, then broken (milled) and fractionated by air classification to produce a hull fraction and a kernel (embryo) fraction. Three drying methods, including oven drying, microwave drying and fluid bed drying, was optimized for efficiency of removing moisture by response surface methodology (RSM) and suitability for the dehulling process. Of the drying methods tested, fluid-bed drying appeared most suitable for the dehulling process with satisfactory drying efficiency. Finally, an optimized flaxseed dehulling process consists of drying of the seeds using fluid-bed dryer, milling by barley Pearler and fractionation of the hull and the kernel (embryo) fractions by air classification. The yield of flaxseed hulls and kernels obtained by the optimized process were 22.6% and 72.2%, respectively. The chemical composition of the hulls was carbohydrates 48.3%, proteins 16.8%, crude oil 26.5%, moisture 5.0% and ash 3.5% compared to that of the embryo fraction (carbohydrates 22.0%, proteins 23.9%, crude oil 47.7%, moisture 3.6% and ash 3.8%) on dry base. Lignans and flaxseed gum are extracted sequentially from the hulls while the kernels, purified by sieving, are used as a food and/or feed ingredient with or without further processing.

Methods for Dehulling of Flaxseed, Producing Flaxseed Kernels and Extracting Lignans and Water-Soluble Fibre from the Hulls

Inventors: Wuwei (Steve) Cui[1] and G. (Joe) Mazza[2]

1: 26 Inverary Drive, Kanata, Ontario, Canada K2K 2R8

2: 187 Stevens Crescent, Penticton, British Columbia, Canada V2A 8A6

BACKGROUND OF THE INVENTION

This invention relates to a novel method and apparatus for dehulling of flaxseed and producing and extracting some novel and useful products, such as flaxseed kernels, lignans and their precursors, water-soluble fibre and flaxseed oil, from the separated hulls and kernels (embryos).

Flaxseed is physically composed of two major components, the hull and embryo. The hull contains a testa layer and an endosperm layer while the embryo is a sole component mainly composed of oil and protein together with cell wall materials (carbohydrates) and some minor constituents. The hull fraction contains water-soluble polysaccharides and lignans and their precursors. Water-soluble polysaccharides can be used as water-soluble fibre which functions as stabilizers in food systems, while the lignans can be used as anti-cancer nutraceuticals. The embryo fraction, here after will be referred to as flaxseed kernels, can be used as food and/or feed ingredient with or without further process.

Flaxseed is cultivated in Canada and USA mainly for oil. Flaxseed meal, the byproduct after oil extraction, is traditionally used as animal feeds. The presence of mucilageous material (mainly water-soluble polysaccharides) in flaxseed meal has caused the under-utilization of this material because of its growth depression effect on poultry (Wolff, 1983; Mandokhot and Singh, 1979). This has the affect of reducing the overall commercial value of flaxseed. Efforts have been made to remove the mucilage in order to improve the nutritional value and functional properties of flaxseed meal (Mandokhot and Singh, 1979; Dev and Quensel, 1989 and Oomah and Mazza, 1993). Most recently, the mucilage from flaxseed has shown strong potential as food or non-food use gum due

to its rheological properties in solution (BeMiller, 1973; Mazza and Biliaderis, 1989, Wannerberger et al., 1991 and Cui et al., 1994a,b). Thus, removal of the mucilage not only improves the nutritional value of flaxseed meal, but also provides a new source for water-soluble hydrocolloidal gums.

An aqueous extraction process has been developed to extract the mucilaginous material (flaxseed gum) from flaxseed (Cui et al., 1994a). At optimum extraction conditions, i.e. temperature (80-85°C), pH (6.5-7.0) and seed to water ratio (1:13), flaxseed gum was obtained with a relative higher yield (7.9%), good quality and less protein contaminants.

In previous reports, flaxseed was under utilized because only one major component was useful in each application. In the present invention, we report a novel, comprehensive method which leads to a full utilization of each major component of flaxseed, i.e. lignans and their precursors, flaxseed gum (water-soluble fibre), flaxseed kernels and cool press oil from the kernels.

SUMMARY OF THE INVENTION

According to the present invention there is provided a method of extracting new and useful products from flaxseed, comprising the steps of drying the seeds to reduce their moisture content to less than about 3%; removing the hulls from the kernels by mechanically friction; separating the hulls and kernels by air classification and sieving; and extracting the useful products, such as lignans, flaxseed gum (water-soluble fibre) and oil from the separated hulls and kernels.

In accordance with the invention, it has been found that the hull (or seed coat) of flaxseed can be physically separated from its embryo layer by removing moisture upon heating or other drying methods. The dried flaxseed can be crushed (milled or broken) mechanically preferably by rubbing/friction mechanism, e.g. in a Barley Pearler. This makes the flat seeds gently rub over against the stone and causes the hulls to separate from the kernels. The crushed (milled or broken) flaxseed contains hulls (seed coats) and embryos (kernels) mostly in the size of half a seed split from the seed centre, which is consequently separated using air flow separation and/or sieving based on size, weight and/or density. Three drying methods, including oven drying, microwave drying and fluid

bed drying, have been tested for efficiency of removing moisture and suitability for the dehulling process. Of the drying methods tested, fluid-bed drying is the most suitable one for the dehulling process with satisfactory drying efficiency. However, microwave oven is the most efficient way for removing moisture.

An optimized flaxseed dehulling process consists of drying of the seeds using a fluid-bed dryer, milling by Barley Pearler and fractionation of the hull and the kernels by air classification and sieving.

Lignans and their precursors are extracted from the hulls using 80-95% ethanol; sequentially, the water-soluble fibre (flaxseed gum) is extracted from the hulls using water, then precipitated in ethanol or concentrated and spray dried.

Flaxseed kernels obtained from the dehulling process can be used directly as food ingredient or additives in foods to add flavour and nutritional values, such as in bakeries, breakfast cereals, snack foods and ingredient for spread products (peanut butter, jams etc.). The kernels can also be further processed by cool press to produce cool-pressed flaxseed oil and de-oiled meals. The cool-pressed flaxseed oil, rich in omega-3 fatty acid, can be used as salad oil and health food product. The de-oiled meal is an ingredient for food application as described for the kernels and could also be used as feed ingredient to improve the nutritional value of feed for animals.

In summary, this invention provides a novel method (processing) and an apparatus for extracting useful products from flat seeds, such as flaxseed, comprising means for drying the seeds to reduce their moisture content to less than about 3%; means for removing the hulls from the kernels of the dried seeds; and means for separating the kernels and hulls to produce hulls and kernels and means of extracting useful products, e.g. lignans and their precursors, water-soluble fibre (flaxseed gum) and flaxseed oil from the respective separated components.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail, by way of example, only with reference to the accompanying drawings, in which:

Figure 1 is a flow chart showing the procedures for a comprehensive utilization of

flaxseed in accordance with the invention;

Figure 2 is a diagrammatic view of a drying apparatus in accordance with the invention;

Figure 3 is a flow chart showing the procedures for dehulling and fractionating flaxseed;

Table 1 shows the yield of fractions obtained by different types of mill; and

Table 2 shows the distribution of hull fractions dehulled by different mills.

Table 3 shows the chemical compositions of flaxseed fractions obtained by air classification; and

Table 4 shows the chemical compositions of flaxseed hull fractions separated by sonic sifting.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in Figure 3, flaxseed is first dried and passed to crusher after which it is passed to low scale air flotation unit to separate the fine fraction F. The residue is then passed to high scale flotation unit to separate the hull fraction H. The residue fraction R is obtained from the high scale flotation unit. The hull fraction is passed through a sonic sifter and separated into fractions H1, H2, H3.

Examples

Flaxseed "Norman", commercially grown in 1991, southern Manitoba, Canada, was used for all experiments. All chemicals used were of reagent grade unless otherwise specified.

Crude oil contents of all fractions were measured using the method of Appelquist (1967) while the protein level was determined as described earlier (Mazza and Biliaderis, 1989). Moisture and ash were determined according to AOAC method (AOAC, 1980) whereas the total carbohydrate content was calculated by differences. All the chemical analyses were carried out in duplicates except the protein content, which was determined in triplicates.

Screening of Dehulling Process

In order to examine the effect of different mill on the dehulling process, flaxseed was milled using four different types of laboratory mills, including a Barley Pearler (A, Strong-Scott Ltd, Winnipeg, Manitoba), a Technilab Micromill (B, Technilab Instruments, Pequannock, N.J.) a Stein Laboratory Mill (C, Model M-2, Atchison, Kansas), and a Thomas Wiley Mill (D, Model 4, 2mm sieve, Thomas Scientific, USA) .

Flaxseed was milled into mixture of hulls and kernels, which then were fractionated using a laboratory air classifier as described by Hergert (1973). The air flow was manually controlled to separate a fine fraction at low scale (2 of 10) and a hull fraction at higher scale (6 of 10). The cutoff of the fine fraction from the hulls was based on preliminary experiment monitored visually.

The residue remained in the cylinder after collection of the hull fraction contained mainly embryo with some unbroken seeds. The unbroken seeds are separated from the embryos by sieving (1/14 to 1/11 sieves) to produce pure and golden flaxseed kernels (embryos).

In order to evaluate the effect of different mills on the sizes of hulls, the hull fraction obtained from air classification was further fractionated into three sub-fractions by size using a Allen-Bradley Sonic Sifter (ATM Cooperation Sonic Sifter, Milwaukee, Wisconsin). Fraction 1 was collected from a 20 mesh sieve, fraction 2 from a 40 mesh sieve and fraction 3 from sieves of 60 mesh and smaller. All procedures for the milling and fractionation were carried out in triplicates.

Seeds were introduced into the Barley Pearler (A) at an approximate rate of 100g seeds/min. The ground mix was dry in both appearance and feeling and composed mainly of large hull and embryo pieces (mostly half pieces) and certain amount of unbroken seeds. Seeds crushed by Micromill (B) was carried out batch-wise (20g seeds per batch, for 10 seconds). The ground mix was dry while the sizes of the hull and embryo fractions were smaller than that from Crusher A but bigger than that from Crusher C (Stein Laboratory Mill) and D (Thomas Wiley Mill) with almost no unbroken seeds observed. For the Stein Laboratory Mill (C), 50g seeds per batch was crushed for 10 seconds. The ground mix was dry and the sizes of the fractions were smaller than that from Crusher A but bigger than from Crusher C (Stein Laboratory Mill) and D (Thomas Wiley Mill)

with almost no unbroken seeds observed.

Flaxseed was introduced into the Thomas Wiley Mill at approximately 100g seeds/min using a 2 mm sieve. The ground mix appeared wet due to the exudate oil which did not occur in the process of other three mills. The particle sizes of the ground mix were the smallest but appeared more homogeneous. There was no unbroken seeds neither fine particles.

The mix of ground flaxseed was fractionated by air classification to obtain a fine fraction, a hull fraction and a residue fraction (kernels). The fine fraction was obtained at low scale (2 of 10) of air flow while the hull fraction at higher scale (6 of 10) based on preliminary experiments. The kernel and some unbroken seeds were collected as the residue fraction (Fig. 3).

As shown in Table 1, yields of fine fractions from different type of mills varied from 0 to 18%, while yields of hull fractions were from 19 to 36% and the residue fractions from 44 to 72% with overall recoveries above 99% . Barley Pearler (Crusher A) yielded 19.6% hull fraction, 7.4% fine fraction and 72.2% residue fraction. The yields of the hull fractions obtained from other mills were between 25 to 36%. The size of these fractions was much smaller compared to that from Crusher A and there were substantial amounts of small embryo pieces present in the hull fractions. For the residue fractions, the yield of AR was the highest (72%) and it contained mostly large size pieces of embryo and substantial amount of unbroken seeds. The yields of BR and CR were 56.3 and 44.2% respectively and both fractions contained mostly of broken embryo with trace amount of unbroken seeds. The yield of DR was 63.4% but it appeared as a mixture of small pieces of hull and kernel fractions. The separation of the hull fraction from the residue was very difficult due to the present of wet oil in the ground mix. Generally, the hull fractions contained higher amounts of carbohydrates and moisture with lower levels of protein and crude oil. In contrast, low levels of moisture and carbohydrates were observed for the residue fractions (Table 3). The protein and crude oil contents of all residue fractions were much higher than that of hull and fine fractions indicating higher contents of embryo component.

The chemical composition of the fine fractions was similar to that of hull fractions

suggesting more hull and less embryo fractions were ground into fine particles for Crusher A, B and C. AH appeared mostly large size hulls with trace but visible amounts of yellow coloured embryo.

AH also contained the highest amounts of carbohydrates (48.2%) and moisture (5.0%) but the lowest amounts of protein (16.8%) and crude oil (26.5%) as described in Table 3. The yield of hull fractions obtained by other three mills (BH, CH and DH) ranged from 24.9 to 36.5%. However, these fractions contained substantial amounts of embryo component as their protein and oil levels were much higher than that of AH (Table 3).

Of all the hull fractions obtained, DH was lowest in moisture and carbohydrate contents, but highest in protein and crude oil with BH and CH in between (Table 3). The amount of carbohydrates in the hull fraction correlated to their moisture content. This is because of the water holding capacity of the water-soluble polysaccharides in the hull fraction. The higher the carbohydrate content, the higher the water holding capacity of the fraction, and therefore, the higher the moisture content. On the other hand, the higher oil content correlated to higher protein content in BH, CH and DH suggesting the present of more embryo fraction in these hull fractions (Table 3).

Since the hull fractions obtained from different types of mills contained various amounts of kernel component with large diversity in size distribution, each of the fractions was further fractionated according to size using a sonic sifter. Three size cut-offs were used to obtain three sub-fractions. The size of the first fraction was larger than 20 mesh, whereas the size of the second fraction was between 20 to 40 mesh and the third fraction was smaller than 40 mesh. The yields of fraction 1 to 3 of the hulls were in a decreased order for AH and DH. In contrast the yield of the second fractions of BH and CH were higher than the other two fractions as shown in Table 2 and Fig. 3. Most of the AH1 fraction was in the size of half seed coat (large size), but the size of BH1, CH1 and DH1 fractions was smaller than a quarter of the seed coat.

These results are in agreement with previous observations that Crushers B, C and D produced smaller pieces of ground mix. The fractionation of DH by sonic sifting was not successful due to the wet oil present in the ground mix which kept the small pieces together by adhesion and remained as large particles (above 20 mesh) in the fraction.

There was no fraction 3 from DH. This is in agreement with the previous observation that Crusher D did not produce fine particles, or, those small particles produced during milling might be sticking together or adhesion on bigger particles which prevented their separations from each other. The chemical composition of the first fraction (AH1 to DH1) varied according to the type of mill used.

DH1 contained lowest carbohydrates and moisture contents but highest amounts of protein and crude oil. This suggests that there is substantial amount of kernel component present in DH1. In contrast, BH1 and CH1 contained highest amounts of carbohydrates, but the lowest protein and oil content indicating that these two fractions contained fewer amounts of kernel component. The chemical composition of AH1 was very close to that of BH1 and CH1 except its carbohydrate content. The second hull fraction (AH2 to DH2) contained much less carbohydrates but substantial higher amounts of protein and crude oil compared to the first fraction (AH1, BH1 and CH1). These findings revealed that there were more kernel component in these fractions than in the first fractions as shown in Table 4.

All the third hull fractions appeared to contain only kernel component with gold yellow colour. Their chemical compositions were comparable to that of residue fractions (Table 3 and Table 4). The ash content of all hull fractions remained relatively constant from 3.4 to 3.8%.

Drying Process and Optimization

Based on preliminary experiments, flaxseed without drying was not suitable for the dehulling process. Significant changes in physical structure of the flaxseed after drying was observed by scanning electron microscopy. Two layers were observed after drying compared to no separation of the hull layer from the embryo without drying. The separation of the hull layer from the embryo upon heat treatment was essential for flaxseed to be dehulled mechanically as described in this invention. Flaxseed without treatment was difficult to dehull because the hull was closely bound to the embryo portion of the seed physically or chemically. The effect of drying methods on the dehulling

process will be discussed.

Flaxseed (1 kg) used for mill type screening test was dried under vacuum (29 in Hg) at 70oC for 6h-the moisture content of the dried samples was zero according to AOAC method (AOAC, 1980). The dried samples were stored in desiccators and cooled to room temperature (22oC) before dehulling process. Since vacuum oven drying is both time consuming and energy inefficient, three industrial available drying methods, including oven drying, microwave drying and fluid bed drying, were examined for efficiency of removing moisture and suitability for dehulling process. A blue M oven drier (Blue M Electric Company, Illinois, USA), a rotatable microwave oven (900w, General Electronics, Canada) and a fluid bed drier (Lab-line/P.R.L, Hi-Speed Model #23350, Canada) were used for removing moisture under conditions described in the experimental design section. The moisture contents of all samples were determined in duplicates using a moisture meter (Denver Instrument Co., Model Marr I, USA). A Barley Pearler, the best miller of the four different type of mills examined, was used for optimization of the milling process. The experimental design was a face centred cube as shown in Table 5. Two independent variables, moisture level (X1) of flaxseed and feeding rate (X2) of the milling process whereas the yield (Y1) and protein content (Y2) of the hull fraction were used to evaluate the milling process. Because of the difficulty of controlling the moisture level of flaxseed by drying, the moisture levels reported in Table 5 were the actual determination of the moisture in the sample dried at different times.

Optimization of Dehulling Process

An optimized flaxseed dehulling process consists of drying of the seeds using a fluid-bed dryer, milling by Barley Pearler and fractionation of the hull and the kernels by air classification and sieving. The yield of flaxseed hull and embryo fractions obtained by this process were 22.6% and 72.2%, respectively. The chemical composition of the hulls was carbohydrates 48.3%, proteins 16.8%, crude oil 26.5%, moisture 5.0% and ash 3.5% compared to that of the embryo fraction (carbohydrates 22.0%, proteins 23.9%, crude oil 47.7%, moisture 3.6% and ash 3.8%) on dry base.

Extractions of Lignans and Flaxseed Gum

The extraction of lignans and flaxseed gum from the hulls are carried out sequentially. Lignans are extracted first by 80-95% ethanol in water under the following conditions: solvent/hulls ratio 10-50 (weight), temperature of 25-60°C extraction time (1-6 hour). The extracts, separated from the hulls by means of filtration, centrifugation or simply decanting, were concentrated by evaporation under vacuum and controlled temperature (preferably under 40oC). The flaxseed gum was extracted from the hulls (after extraction of lignans) using water as the extraction solvent. The water/hulls ratio was 20-60, while the extraction time was 1 to 3 hr with pH of 7-9 and temperature of 75-85oC. The extracted gum solution/dispersion was separated from the hulls by filtration and/or centrifugation. The gum solution/dispersion (free of solid material) is precipitated in 3-4 volumes of ethanol and dried or concentrated and than spray dried.

The invention thus enables the hulls and kernels to be separated and useful products to be extracted from the separated products.

REFERENCES:

AOAC. 1975. AOAC Official method.

Appelquist, L.A. 1967.J. Amer. Oil Chem. Soc., 44:209-214.

BeMiller, J.N. 1973. In "Industrial gums", 2nd ed. (ed. R.L. Whistler). pp.339-367. Academic Press, New York.

Cui, W., Mazza, G. and Biliaderis, C.G. 1994a. Chemical structure, molecular size distribution and rheological properties of flaxseed gum. J. Agricult. Food Chem., 42:1891-1895 .

Cui, W., Mazza, G., Oomah, B.D. and Biliaderis, C.G. 1994b. Optimization of an aqueous extraction process of flaxseed gum by response surface methodology. Lebenms.-Wiss. u.-Technol., 8:363-369.

Hergert, G.B. 1973. A laboratory classifier for separation of ground products by terminal velocity. Can. Inst. Food Sci. Technol. J. 6:298-299.

Mandokhot, V.M. and Singh, N. 1979. Studies on linseed (Linum usitatissimum) as a protein source for poultry. I. Processes of demucilaging and dehulling of linseed and evaluation of processed materials by chemical analysis and with rats and chicks. J. Food Sci. Techn., 16:25-31.

Mazza, G. and Biliaderis, C.G. 1989. Functional properties of flaxseed mucilage. J. Food Sci., 54:1302-1305.

Oomah, B.D. and Mazza, G. 1993. Processing of flaxseed meal: effect of solvent extraction on physico-chemical characteristics. Lebensm.-Wiss. u.-Technol. 26:312-317.

Tkachuk, R. 1969. Cereal Chem. 46:419-423.

Wannerberger, K., Nylander, T. and Nyman, M. 1991. Rheological and chemical properties of mucilage in different varieties from linseed (Linum usitatissimum). Acta Agric. Scand. 41:311-319.

Table 1. Yield of fractions of flaxseed dehulled by different crushers.

Crusher Type	Fine Fraction (%)	Hull Fraction (%)	Residue Fraction (%)	Recovery (%)
A[a]	7.4±0.7[b]	19.6±1.7	72.2±2.7	99.2±0.5
B	18.1±1.7	24.9±0.4	56.3±2.1	99.4±0.6
C	18.2±1.9	36.5±1.0	44.2±1.8	99.0±0.8
D	0.0±0.0	36.3±1.8	63.4±1.7	99.7±0.5

a: A, Barley Pearler, Strong-Scott Ltd, Winnipeg, Manitoba
B, TechniLab Micromill, Technilab Instruments, Pequannock, N.J.
C, Stein Laboratory Mill, Model M-2, Atchison, Kansas
D, Thomas Wiley Mill (2mm seive), Model 4, Thomas Scientific, USA

b: Mean ± S.D, n=3

Table 2. Distribution of hull fractions obtained by sonic sifting.

Crusher Type	Fraction H1[a] (%)	Fraction H2[b] (%)	Fraction H3[c] (%)	Recovery (%)
A[d]	81.7±3.0[e]	12.3±1.7	5.4±1.3	99.4±0.2
B	42.0±2.1	45.8±1.0	12.3±1.3	100.0±0.0
C	30.3±3.0	55.2±3.6	14.2±0.3	99.7±0.5
D	73.2±15.4	26.6±15.4	0.0±0.0	99.8±0.2

a: Size > 20 mesh.
b: 40 mesh<size<20 mesh.
c: Size < 40 mesh.
d: see description of Table 1.
e: Mean ± S.D, n=3.

Table 3. Chemical composition of flaxseed fractions obtained by air classification

Sample	Moisture (%)	Protein (%)	Crude Oil (%)	Carbohydrate (%)	Ash (%)
AH[a]	5.0±0.0[b]	16.8±0.4[c]	26.5± 0.1[b]	3.5±0.0[b]	48.2±1.1[d]
BH	3.5±0.1	18.7±0.2	36.8±0.5	3.5±0.1	36.5±1. 0
CH	3.9±0.1	19.8±0.3	35.3±0.1	3.4±0.1	37.6±1.1
DH	3.1±0.0	20.4±0.1	38 .0±0.5	3.6±0.1	34.9±1.0
AR	3.6±0.0	23.9±0.3	47.7±0.1	3.8±0.1	22.0±0. 6
BR	2.7±0.1	24.4±0.4	49.3±0.2	3.9±0.0	19.7±0.3
CR	2.4±0.0	24.3±0.2	48 .3±0.2	4.0±0.0	21.0±0.2
DR	2.7±0.0	22.8±0.1	43.4±0.5	3.9±0.1	27.2±0. 7
AF	4.8±0.1	19.1±0.1	33.3±0.1	3.9±0.0	38.8±0.8
BF	3.8±0.0	20.8±0.1	36. 3±0.0	3.7±0.1	35.3±0.1
CF	4.0±0.0	20.5±0.2	35.7±0.1	3.8±0.0	36.0±0.4
DF	---e	---	---	---	---

a: A, B, C, D represent type of crusher, see Table 1; F, H and R represent the fine fraction, hull fraction and residue fraction, respectively.
b: Dry base, Mean±S.D. n=2.
c: Dry base, Mean±S.D. n=3, N% X 5.41 (Tkachuk, 1969).
d: Dry base, calculated by differences.
e. Not determined.

Table 4. Chemical composition of flaxseed hull fractions separated by sonic sifting.

Sample	Moisture (%)	Protein (%)	Crude Oil (%)	Carbohydrate (%)	Ash (%)
AH1[a]	5.0±0.1[b]	17.6±0.2[c]	26.0 ±0.0[b]	3.5±0.0[b]	47.9±1.0[d]
AH2	5.3±0.1	22.3±0.2	36.7±0.3	3.5±0.0	33.2± 0.8
AH3	4.0±0.0	23.6±0.2	39.2±0.6	3.6±0.0	29.6±0.5
BH1	4.5±0.0	15.7±0. 2	24.7±0.4	3.6±0.0	51.5±0.8
BH2	3.2±0.0	21.0±0.4	40.4±0.3	3.5±0.0	31. 0±0.6
BH3	2.7±0.0	25.1±0.4	48.2±0.0	3.5±0.0	19.5±0.3
CH1	4.6±0.0	15.7 ±0.2	24.9±0.4	3.4±0.0	51.4±0.8
CH2	3.4±0.0	22.5±0.3	40.6±0.5	3.5±0.1	30.0±0.9
CH3	2.6±0.2	25.1±0.2	49.0±0.2	4.0±0.1	19.3±0.5
DH1	3.8±0.0	2 0.0±0.1	30.0±0.1	3.7±0.0	32.5±0.2
DH2	3.2±0.0	23.5±0.2	42.5±0.1	3.8± 0.0	27.0±0.2
DH3	---e	---	---	---	---

a: A, B, C, D represent type of crusher, see Table 1; H1, H2 and H3 are the respective three fractions obtained by sonic sifting, see Table 2.
b: Dry base, Mean±S.D. n=2.
c: Dry base, Mean±S.D. n=3, N% X 5.41 (Tkachuk, 1969).
d: Dry base, calculated by differences.
e. Not determined.

Table 5: Variables and experimental data for the two-factor, three-level responsesurface design of the dehulling process of flaxseed.

Run Order	Microwave Drying				Fluid Air Drying				Oven Drying			
	X1*	X2	Y1	Y2	X1	X2	Y1	Y2	X1	X2	Y1	Y2
1	1.73	200	18.36	17.00	1.96	200	19.14	17.25	2.35	200	11.90	17.60
2	1.73	1200	11.36	17.90	1.75	1200	9.95	18.30	2.35	1200	4.61	18.50
3	5.78	200	9.60	16.70	5.12	200	15.23	17.90	5.42	200	9.33	17.55
4	5.76	1200	14.10	22.05	5.17	1200	6.17	19.50	5.09	1200	3.49	18.55
5	1.86	600	23.79	20.45	1.86	600	11.95	17.55	2.42	600	5.96	17.35
6	5.85	600	7.59	20.25	5.56	600	7.09	18.40	4.64	600	4.33	17.85
7	3.86	200	22.73	16.65	2.52	200	20.84	18.45	4.29	200	8.71	17.35
8	3.32	1200	5.71	17.85	2.68	1200	7.11	17.90	3.48	1200	3.01	18.30
9	3.19	600	16.59	18.40	2.79	600	11.97	18.10	2.99	600	4.87	17.60
10	3.33	600	9.78	19.10	2.77	600	12.32	18.10	3.03	600	6.10	17.90
11	3.52	600	7.85	18.80	2.70	600	11.73	18.70	3.30	600	5.35	18.00

*: X1, Moisture Content (%)
X2, Feeding Rate (g/min)
Y, Yield of Hulls (%)

I claim:

1. A method of extracting useful products from flaxseed, comprising the steps of:

a) drying the seeds to reduce their moisture content to less than about 3%;

b) removing the hulls from the kernels;

c) separating the hulls and kernels;

d) purifying flaxseed kernels (embryos);

e) extracting the useful products from the respective separated hulls and kernels and

f) applications of flaxseed kernels (embryos) as food ingredient or additives for human and animal consumptions.

2. A method as claimed in claim 1, wherein said hulls and kernels are separated mechanically.

3. A method as claimed in claim 2, wherein said hulls and kernels are separated by gently rubbing and/or friction the seeds against stone disks.

4. A method as claimed in claim 1, wherein the seeds are dried to reduce their moisture content to less than about 3%.

5. A method as claimed in claim 1, wherein the hulls and kernels are separated by air fractionation.

6. A method as claimed in claim 5, wherein the said kernels are purified by sieving to remove the unbroken seeds.

7. A method as claimed in claim 1, wherein the seeds are dried using a fluid bed drier or microwave oven.

8. A method as claimed in claim 1, wherein said flat seeds are flaxseed.

9. A method as claimed in claim 6, further comprising extracting lignans and water-soluble fibre (gum) from the separated hulls.

10. A method as claimed in claim 9, wherein said lignans and gum are extracted sequentially.

11. A method as claimed in claim 10, wherein said lignans are first extracted in 80-95% ethanol in water under the following conditions: solvent/hulls ratio 10-50 (by weight), temperature 25-60°C, time 1-6 hours.

12. A method as claimed in claim 11, wherein the hull is then extracted in water.

13. A method as claimed in claim 12, wherein the extraction of the flaxseed gum takes place under the following conditions: water/hulls ratio, 20-60 (by weight); extraction time is 1 to 3 hours; pH, 7-9; and temperature 75-85°C.

14. An apparatus for extracting useful products from flat seeds, such as flaxseed, comprising:

a) means for drying the seeds to reduce their moisture content to less than about 3%;

b) means for removing the hulls from the kernels of the dried seeds; and

c) means for separating the kernels and hulls so that the useful products can be extracted from the respective separated components.

15. An apparatus as claimed in claim 14, wherein said removing means comprises means for mechanically agitating the dried seeds.

16. An apparatus as claimed in claim 15, wherein said removing means comprises

means for causing the dried seeds to rub gently against stone disks.

17. An apparatus as claimed in claim 14, wherein said separating means comprises a column for containing the mixture of hulls and kernels, and a blower for blowing air through the column so that the hulls rise above the kernels and are separated by air fractionation.

18. An apparatus as claimed in claim 17, wherein said column includes a conical baffle for catching the separated hulls, said baffle having a central opening through which the rising hulls pass.

19. An apparatus as claimed in claim 14, wherein said separating means comprises a sieve.

20. An apparatus as claimed in claim 18, wherein said removing means comprises a Barley Pearler.

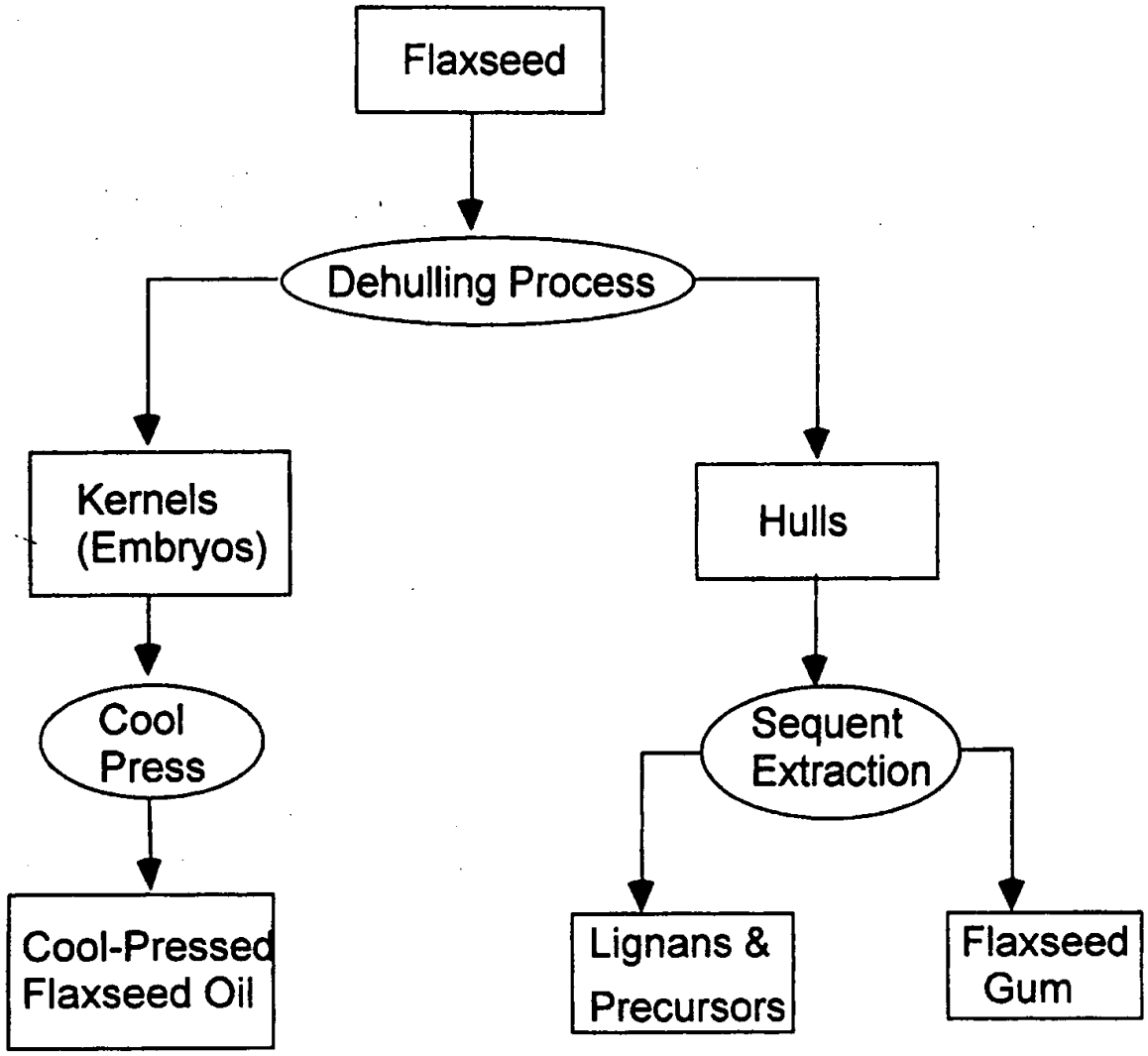
Flaxseed
Dehulling Process
Kernels (Embryos)
Hulls
Cool Press
Sequent Extraction
Cool-Pressed Flaxseed Oil
Lignans & Precursors
Flaxseed Gum

Figure 1

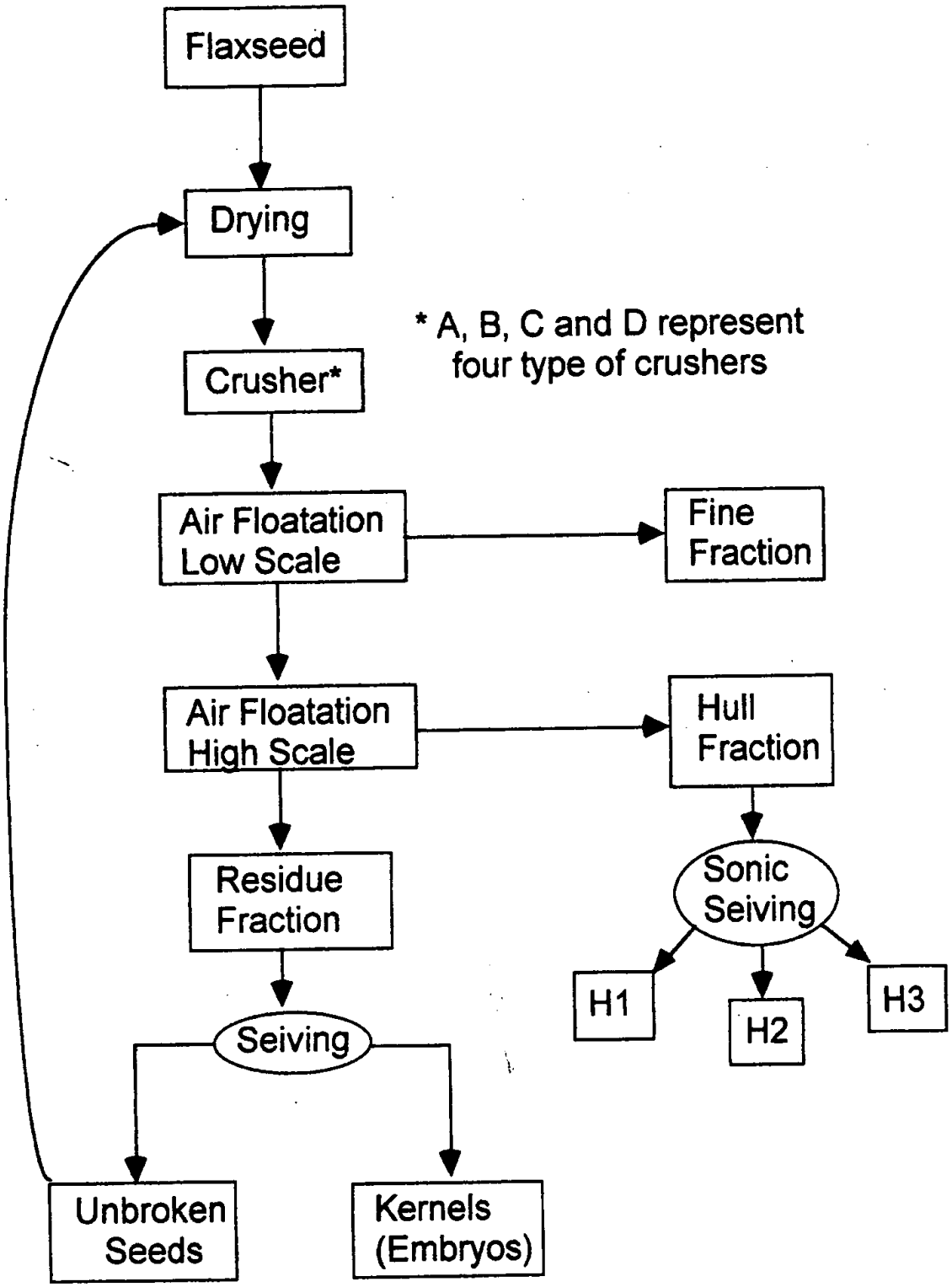
Flaxseed
Drying
Crusher*
* A, B, C and D represent four type of crushers
Air Floatation Low Scale
Fine Fraction
Air Floatation High Scale
Hull Fraction
Residue Fraction
Sonic Seiving
H1
H2
H3
Seiving
Unbroken Seeds
Kernels (Embryos)

Fig. 2

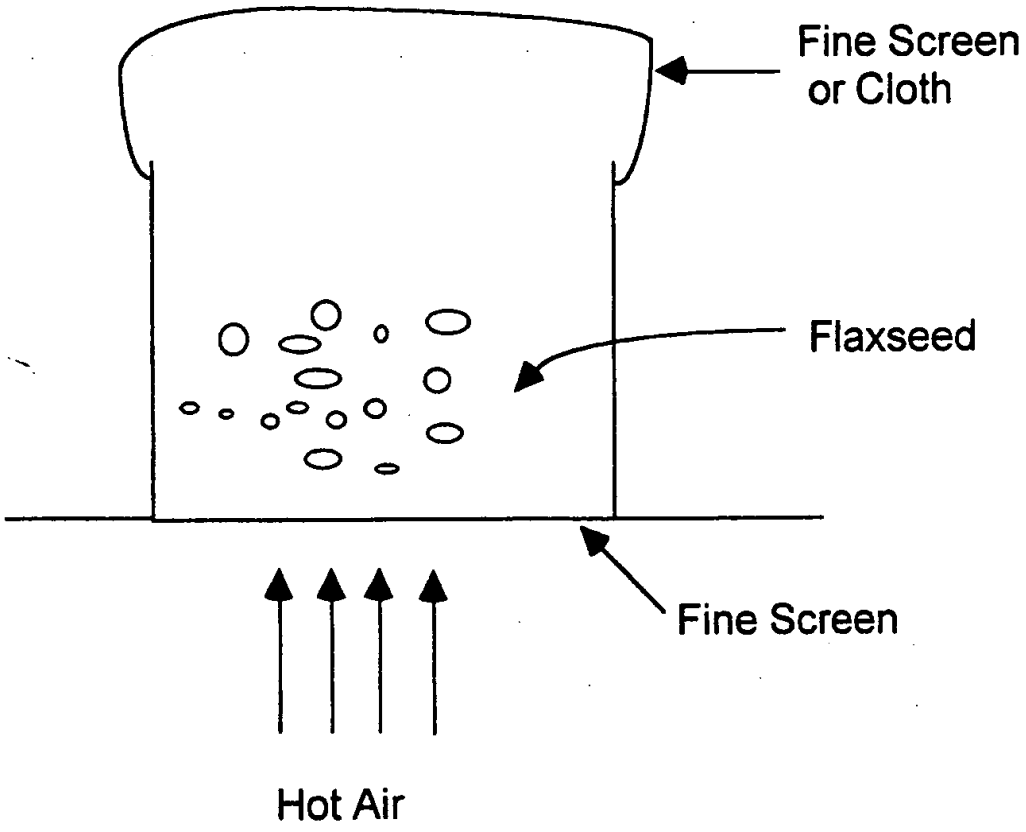

Figure 3